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Gender-related differences in computer-mediated communication and computer-supported collaborative learning

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Abstract A question associated with the introduction of computer-supported collaborative learning (CSCL) is whether all participants profit equally from working in CSCL environments. This article reports on a review study into gender-related differences in participation in CSCL. As many of the processes in CSCL are similar to those in computer-mediated communication (CMC), studies into CMC are also included in the review. Male dominance is found to play a role in many CMC settings. A learning culture with an explicit focus on participation by all students seems to be related to a more gender-balanced participation in CMC, however. A tendency for boys to be more active participants than girls is also present in CSCL environments, but it is less pronounced than in CMC. This may be explained by the fact that participation is explicitly promoted in most CSCL environments. Gender differences in the character of students' contributions are found in both CMC and CSCL. It is concluded that in order to avoid gender-stereotyped participation and communication patterns, it is necessary to explicitly address inclusiveness as an aspect of a collaborative classroom culture. A plea is made for further research into differential participation by students in CSCL, and the effects thereof on cognitive and affective learning outcomes. Research should also focus on the question how classroom cultures can be promoted that support active participation of all students aimed at collaborative knowledge construction.

Keywords computer-mediated communication, cooperative/collaborative learning, gender studies, improving classroom teaching.

Introduction

One of the educational uses of information and communication technology (ICT) that is currently receiving a good deal of attention is computer-supported collaborative learning (CSCL). CSCL is based on a number of theoretical notions developed in the field of collaborative learning and in socio-constructivist educational theories. Studies into collaborative learning emphasize the importance of positive interdependence, socio-cognitive conflict, resource sharing and verbalizing thoughts for learning (see Cohen 1994; Johnson & Johnson 2003; Terwel 2003). Socio-constructivist educational theories explain how collaborative knowledge building and participation in meaningful problem solving enhance learning (e.g. Scardamalia & Bereiter 1994). There are a number of different applications that come under the heading of CSCL. One element they have in common is student collaboration in an electronic learning environment that invites exchanges of ideas and arguments and in which knowledge is

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constructed collaboratively. CSCL applications aim at promoting deep learning by the participants in this process of knowledge construction.

Empirical research on CSCL has shown that CSCL may, in fact, facilitate deep learning. Also, motivational benefits resulting from the use of CSCL are reported (Lehtinen *et al.* 1999; Lipponen *et al.* 2003). However, in some cases, students appear to participate less in electronic discussions than is desirable (Guzdial 1997; Lipponen 1999; Guzdial & Turns 2000), and students' contributions do not always result in collaborative knowledge building (Lipponen *et al.* 2003). The question has also recently been posed whether all participants profit equally from working with CSCL. The idea behind (computer-supported) collaborative learning is that learning is achieved when students actively participate in verbal interactions that are aimed at finding joint solutions. However, it may be assumed that students do not all participate to the same extent and in the same way in CSCL as a matter of course. Like in other educational forms, patterns of participation may be related to the ability, social and ethnic background and gender of students.

This article reviews what is known about gender-related differences in participation and learning outcomes in CSCL environments and in computer-mediated communication (CMC). In learning through CMC, electronic discussion is used as a means of enhancing students' exploration and understanding of the subject matter. In CSCL, communication and discussion are aimed at solving problems or building knowledge collaboratively, and collaboration is supported by specifically designed software. Our primary interest was in CSCL. However, only a limited number of studies address the issue of gender differences in CSCL environments. In the field of CMC, gender has been a topic for research for quite some time. As learning through CMC and CSCL do have a number of characteristics in common, we think research into gender differences in CMC may be informative for CSCL.

Gender differences in the use of educational technology have been found, as ICT was introduced in schools. Research has shown that ICT learning environments easily provoke gender-stereotyped patterns of interaction. Boys tend to adopt expert roles, whereas girls position themselves as outsiders in relation to the computer. Girls focus more on the group process when working together on the computer, whereas boys more often concentrate exclusively on the computer itself (Volman & van Eck 2001). Studies worldwide show gender differences in computer attitudes (e.g. Comber *et al.* 1997; Huber & Schofield 1998). Boys appear to find computers more attractive and feel more confident about their own computer skills than girls. Research has also focused on the role of the gender composition of computer-using groups. Some studies found that girls do better in same-gender groups, others show that girls perform better in mixed groups. It is generally agreed, however, that in mixed pairs boys usually control the work being performed on the computer (Barbieri & Light 1992; Underwood *et al.* 2001). It should be noted also that gender differences in both participation and attitudes are less common in younger students than in older students and do not manifest themselves in identical ways in relation to every ICT application. Girls appear to be particularly interested in interactive technology that encourages communication, collaborative learning, the solving of complex social dilemmas, intensive writing and flexible problem solving (AAUW Educational Foundation Research 2000). In CMC and CSCL, communication plays an important role.

We consider gender differences mainly as reflecting the results of varying socialization processes. However, the 'results' of socialization are not fixed or unequivocal. The extent to and the way in which gender-related attitudes, communication styles and preferences are enacted in the classroom is related to a number of factors, such as the gender regime of the classroom (Kessler *et al.* 1985), the domain and the gendered character of the educational technologies used (Wajcman 2004). In this article, we are interested in gender differences as they occur in two particular kinds of technology-enhanced learning, i.e. learning through CMC and CSCL.

The literature on gender differences and ICT, briefly summarized above, prompted a number of questions to be investigated in our review. First, we wondered whether gender differences would occur in the degree of students' participation in CMC and CSCL. As working with ICT is involved, a lesser participation of girls may be expected, but on the other hand, CMC and CSCL both have a number of features that have been found to be attractive for girls (interaction, collaboration, writing and problem solving). We are interested not only in the extent to which students participate but also in the character of their contributions in the group process.

Therefore, a second question focuses on gender-related types of participation. Finally, participation in whatever learning environment is not a goal in itself, it is aimed at realizing certain learning goals. Therefore, a third question concerns what is known about gender-related outcomes of learning in CMC and CSCL. These questions will be answered separately for CMC and CSCL. CMC studies into gender differences are reviewed in the first part of the article. The second part of the review focuses on CSCL.

Methodology

In order to answer the question what is known about gender differences in participation and learning outcomes in CMC and CSCL environments, a literature search was carried out in Education Resources Information Centre (ERIC) (journal articles and full-text), online contents and our own universities' online journal database. The descriptor GENDER was combined with the descriptors CSCL, and combinations of EDUCATION, DIFFERENTIATION, COMPUTER SUPPORT, TECHNOLOGY, COLLABORATION, COOPERATION and COMMUNICATION. We limited ourselves to recent (post-1990) reports in peer-reviewed journals, articles presented at international conferences and contributions in books. Research on the topic under discussion is very rare before 1995. The abstracts of the articles were checked for the light they might shed on our research question. In addition to the computer search, the reference sections of recent articles were examined for appropriate material. The relevant journal articles were found either online or in university libraries. If the articles found were of particular relevance, the journal was checked for further articles on the subject (quick search within the journal). The search produced six relevant titles.

In addition, we carried out a limited search using the descriptors COMPUTER-MEDIATED COMMUNICATION and GENDER, and followed the same procedure as described above. This resulted in 13 titles being included in the review.

The CMC and CSCL studies were analysed in the following way. First, they were each described in terms of their research question, as well as the kinds of differences reported in the study in question, the design of the study, the research group (N, grade-level, etc.), the methods used, the research context (including the application used, the instruction/task, subject area, grouping of students) and the results of the study. The results were analysed and divided into the following three themes: first, gender differences in the quantity of participation; second, gender differences in the kind or quality of participation; and, third, gender differences in learning outcomes.

Gender differences in CMC

Research in the field of gender differences in CMC mainly concentrates on differences in participation and communication styles and patterns. Both these issues are discussed in this section. Relevant details of the studies are summarized in Table 1.

Gender differences in degree of participation

Research results are not unequivocal on the question whether student participation in electronic discussions is gender-equitable, and whether this is more or less so in CMC than in face-to-face discussions. Initially, equalizing effects of CMC were claimed, based on the idea that social clues are absent in electronic discussions (e.g. Harasim 1987). Soon, however, several authors argued that gender-based communication styles found in face-to-face communication, and therefore the power dynamics and biases associated with these styles, carry over into electronic environments (Gay 1999) and that social cues are also present in written language (Fabos & Young 1999). Herring (1993) was among the first researchers who showed patterns of male dominance in computer-mediated discussion lists. In an early study, Selfe and Meyer (1991) found that men also dominate online conference communications. They studied a discussion of 18 male and 15 female adult participants who used an online conference as follow-up to a face-to-face conference. Degree of domination or communication style turned out not to be influenced by participants' option of using pseudonyms.

Empirical studies also found that male students tend to dominate the discussion in situations where CMC is used for educational ends. Barrett and Lally (1999) studied 16 first-year postgraduate students of educational studies or English language teaching (11 women, five men) who had only limited opportunities to meet their tutors or other students, and consequently used their own computers to access an Internet email account that enabled them to communicate with each other. The

Table 1. Details and results of the CMC studies.

References	Number of subject, level	(Main) objective/ research question	Design	Methodology: data	Application, task and content	Grouping	Instructions (structure provided for interaction)	Results
Adrianson (2001)	*n* = 60, doctoral students (mean age = 29)	Group processes in problem solving	Two conditions – CMC vs. face-to-face	Message count and word count and qualitative analysis (coding)	Eudora email. General decision task – unstructured problems generating group discussion	12 groups: 2 groups – 3 M, 2 F 4 groups – 3 M, 2 F 4 groups – 2 M, 3 F	No private emails, only public. Find a solution that all could accept	Communication in CMC more or less balanced. Females: more agreeing and more opinion change
Barret and Lally (1999)	*n* = 16, postgraduate	Differences and relations of men and women	Descriptive	Message count, word count, qualitative content coding	Asynchronous Mailbase system. Educational studies or English language teaching. Online seminar	Whole group; 11 F, 5 M	Open group discussion	Males sent more messages during email discussions. Females: more task attuned, more building on
Bernard *et al.* (2000)	*n* = 54, college (mean age = 23)	Male and female attitudes towards computer-mediated group interactions	No control	Questionnaire	Synchronous three-way communication software. General decision task. Ranking task on survival in the subarctic	Groups of three, gender masked (total: 32 F, 22 M)	Rank the survival items first individually then as a group. Reach a consensus in 45 min	Males: more confident, more satisfied with interaction and lower levels of computer anxiety
Carr *et al.* (2004)	*n* = 98, university (3rd year)	The extent and nature of student participation from a community of practice perspective	Descriptive	Exchange Structure Analysis, extent and nature of student participation	Text chat. Economics. Trade bargaining	Total: 44 F, 54 M, group 1: 3 F, 8 M, group 2: 3 F, 6 M	Unfacilitated online chats, negotiation in a goal-focused game	Number of turns by males 18.5% higher than of females. Females: more focus on collaboration. Males: adverse
Gay (1999)	*n* = 100, university	Group processes in problem solving	Two conditions – CMC vs. face-to-face	Content analysis	CoNote. Computational thinking and computer programming. Posting comments on a site	2–3 persons per group	Working on their own sites, plus requirement to comment on three other students' sites	Social cues are also present in written language

Table 1. *Continued*

References	Number of subject, level	(Main) objective/ research question	Design	Methodology: data	Application, task and content	Grouping	Instructions (structure provided for interaction)	Results
Selfe & Meyer (1991)	*n* = 33, university	Gender and power relationships	Case study, 40 days (20 days anonymous)	Message and word count. Content coding (e.g. agreeing and disagreeing)	Megabyte University. Electronic conference. Sending messages and texts. English, writing, literature	(15 F, 18 M), first part: regular, second part under pseudonyms	–	Men dominate communications. Men: more assertive, initiating, disagreeing more
Hsi and Hoadley (1997)	*n* = 165, middle school	Comparing gender differences in participation between class discussion and MFK discussion	Experimental: face-to-face vs. electronic discussion	Entry count, read count, qualitative coding	Multimedia Forum Kiosk. Discussing questions. Experimental physical science (heat, light, sound, energy)	Groups of 15, equal numbers of boys and girls assigned randomly	Need to make at least three comments to MFK and at least one contribution to class discussion	Participation in electronic discussions was more equitable. Females participated more. Girls preferred electronic discussions.
McConnell (1997)	*n* = 27, late 20s to early 50s	Patterns of interaction	Naturalistic, extended period (3–7 months)	Textual analysis, interaction patterns	Caucus computer conferencing system, asynchronous, designing and evaluating a program. Self-selected issues, management	Total: 11 F, 16 M, group 1: 2 F, 2 M, group 2: 2 F, 3 M, group 3: 6 F,7 M, group 4: 1 F, 4 M	Participation obligatory	Females took more turns, males entered more words per turn. No differences in directing the conversation.
Savicki *et al.* (1996a)	*n* = 36, undergraduate	Amount and type of participation of women and men	Three conditions (group composition)	Messages and word count, content analysis (conflict). Questionnaire	Pegasus Mail Software, ranking fictional characters on morality of their actions, psychology	Groups of 6: FO, MO, MIXED	First complete individual ranking. Required to check the electronic mailboxes at least twice a week. Arrive at a group ranking	FO: more words, more satisfied with group process and communication aspects, higher in group development
Savicki *et al.* (1996b)	*n* = 72, undergraduate	Gender, group composition and task type	Experimental. Two conditions of task type (feminine, masculine)	Message and word count, Content Analysis (conflict), Questionnaire, Team Development Scale	Pegasus Mail Software, feminine content: decision making, masculine content: intellective choice, psychology	FO, MO, evenly mixed (4–6 members)	Training for use of Pegasus Mail Software. All group communication via email. Requirement to check mailboxes at least two times a week	MO: more tension, more abusive language, less opinion change. FO: more opinion and mild or intense reactions

Table 1. *Continued*

References	Number of subject, level	(Main) objective/ research question	Design	Methodology: data	Application, task and content	Grouping	Instructions (structure provided for interaction)	Results
Savicki *et al.* (1996c)	*n* = 30, groups, ? Average of 46.2 contributors per group	Relatedness between gender roles and group process functions described as task and maintenance, as found on the Internet	Naturalistic/ descriptive	Content Analysis (fact, apology, first person flaming, status, etc.)	Different Internet discussion forums, general discussion, various issues	27 groups – different gender distributions (73% men). Mean = 46.2 participants, all male majority	–	Male groups: fact-oriented, calls for action. Female groups: self-disclosure, tension prevention, less responding
Savicki *et al.* (1999)	*n* = 69, undergraduate	Pattern of relationships between gender composition and group activity	Two instruction conditions (standard online etiquette or group development)	Message and word count, Content Analysis, Questionnaire, Team Development Scale	Pegasus Mail Software, ranking fictional characters on morality of their actions, psychology	FO, MO, MIXED groups of 4–6 members	Encouraged to read the guidelines. Experimental: encouraged use of 'I' messages, opinions, direct recognition and conversation, avoidance of harsh argumentativeness	Boy groups: more arguments, attacks and responses to attacks. Girl groups: more individual opinions
Savicki *et al.* (2002)	*n* = 64, undergraduate	Group gender composition and communication styles	Experimental. High communication style training and control group	Message and word count, Content Analysis (conflict), Questionnaire, Team Development Scale	Electronic mail, LISTSERVE, ranking fictional characters on morality of their actions, psychology	(35 F, 29 M), FO, MO, MIXED 11 groups. 4 MO, 4 FO, 3 MIXED	Required participation two times a week. Sharing their perceptions and discussing issues in order to arrive at a group ranking	?
Wolfe (2000)	*n* = 58, 20–24 years	Participation differences	Descriptive (face-to-face vs. CMC)	Word count, Questionnaire	InterChange, ?, English	(41 F, 17 M)	Students prepared materials for discussion and were encouraged to call on one another	Gender and ethnicity interact. White females: participation increased, strong preference for CMC

CMC, computer-mediated communication; F, female; FO, female-only; M, male; MFK, Multimedia Forum Kiosk; MO, male-only.

authors found that males sent more messages during email discussions.

Carr *et al.* (2004) looked at participation patterns in a third-year university economics module (a trade bargaining simulation), including a mixture of online communication and face-to-face meetings. In the two groups they studied, more than two-thirds of the participants were male. They found that the online discussions were dominated by a small number of male students, but that, conversely, some of the least vocal students were also male. Female students averaged 124 turns across the series of chats, the average number of turns by male students was 18.5% higher.

Adrianson (2001) studied 30 male and 30 female doctoral students who were set the task of solving two problems with ambiguous solutions. The students, who had volunteered to participate in the study, were divided into 12 groups: four groups engaged in face-to-face discussion and eight groups in CMC. The gender distribution of these groups was more or less balanced. She found that the communication in a CMC condition was also more or less balanced. In face-to-face communication, females produced more messages than the male participants, however.

Group composition also seems to play a role in CMC. In an experiment that included 72 undergraduate psychology students, Savicki *et al.* (1996a) studied the role of gender, group composition and task type in CMC. Gender group composition included females only, males only, and evenly mixed male and female groups (group sizes ranging from four to six members). The groups were newly formed and had no previous history of interaction. All subjects participated in a 1-h hands-on training session in the use of email software before completing a decision-taking task and an intellective choice task. All group communication took place via email and students were required to check their mailboxes at least twice a week. Analyses showed that female-only groups appeared to send significantly more words than either mixed or male-only groups.

Some authors, however, do find equitable participation of male and female students in CMC, also in mixed discussion groups. Hsi and Hoadley (1997) report on a study in which electronic discussion was used with eighth grade students ($n = 165$) acquiring the basics of thermodynamics, and compared with ordinary classroom discussions. The study was explicitly intended to identify key features of electronic discussion for supporting gender-equitable opportunities and productive discussions in science. The males and females in this study were assigned randomly to the groups in equal numbers. Student participation in electronic discussions appeared to be more gender-equitable than in the ordinary discussions; females participated more than males in electronic discussions, whereas they participated less in class discussions. Moreover, girls appeared to prefer electronic discussions to face-to-face classroom discussions.

McConnell (1997) conducted an extensive study into patterns of interaction in four small, mixed-gender groups of postgraduate students working in a computer conference environment. This conference was an integral part of a larger programme, in which participants and tutors also met in face-to-face workshops, and that was organized with a view to work as a learning community. Eleven females and 16 males participated in the study, with ages ranging from late twenties to early fifties. In every group the males slightly outnumbered the females. In three out of the four groups, however, females took more turns than males, although there still seemed to be a trend for males to enter more words than females per turn. Only in one group females entered more total words. No major differences occurred in who directed the conversation, when measured in terms of who sets up new items. McConnell (1997) concludes that CMC, by altering expectations, behaviour and group dynamics, offers potentially greater equality of participation for females in mixed-gender learning settings.

Masters and Oberprieler (2004) demonstrate how they achieved a high degree of participation and a low level of male dominance in the online discussions of 311 students in a faculty of health sciences, through a number of measures. New curricula were introduced in the faculty, characterized among others by a greater integration among the various divisions and courses, and a strong emphasis on experiential and problem-based learning. The same methods as well as the same educational philosophy and content was used in online discussions as in the face-to-face curriculum activities. Other measures in the online discussions were ensuring that all students are ICT-literate, asking questions that are important to the students' course of study and allowing unhindered debate.

It is striking that the three contexts, in which positive results were achieved in terms of gender equality in

participation, are characterized by either an explicit focus on inclusiveness or a broader pedagogical focus on for example 'productive discussion' or 'creating a learning community' in which all students participate. The studies, in which male dominance of the discussion was observed, are either not explicit on the pedagogical principles that guided the course or programme, or describe experimental situations in which students, who were randomly assigned to face-to-face or online conditions, were asked to solve a problem or complete a task.

A study by Wolfe (2000) shows that gender does not influence participation in CMC for different groups of students in the same way. Gender and ethnicity appeared to interact in her study. In total, 41 females and 17 males between 20 and 24 years of age participated in a traditional face-to-face classroom discussion and in a computer-mediated discussion in three undergraduate English classes. The relative participation of white women increased by over 50% in the computer-mediated environment. However, this increase in participation was not shared by the Hispanic women.

Differences in kind of participation

A number of studies have focused on gender-based communication styles in CMC. In the study of Selfe and Meyer (1991) cited earlier, men were found to be more assertive in the discussion than women, initiating three times as many topics as women and disagreeing with others twice as often. However, no differences were found in the number of agreements, apologies and questions.

Savicki *et al.* (1996b) measured the level of conflict in differently gender-composed groups of undergraduate psychology students in two task situations: a decision-making task and an intellective task. Male-only groups had the largest percentage of messages containing tension (attacking an opposing argument), followed by mixed groups, with female-only groups demonstrating no tension. Male-only groups used more abusive language and changed their opinions less. Female-only groups appeared to produce the largest percentage of messages containing opinion, followed by male-only groups. Female-only groups also had the largest percentage of messages containing mild or intense reactions to other persons in the group, followed by the mixed group. Contrary to the authors' hypothesis, male-only groups did not use more fact-language.

Savicki *et al.* (1996a) analysed a sample (2692 messages) from 30 randomly selected discussion groups. The messages were coded for language content that had in other research been related to gender role. In groups with higher proportions of males, subjects used more fact-oriented language and more calls for action. Subjects in groups with lower proportions of males used more self-disclosure and more attempts at tension prevention and reduction. Subjects responded less to others in the group when the proportion of males was low. Savicki *et al.* (1999) elaborated on this issue. In their study, boys groups communicated more with arguments, attacks and responses to attacks, whereas girl groups tended to vent more individual opinions.

In the Barrett and Lally (1999) study mentioned earlier, the women appeared to be more attuned to the task and more interactive in email discussions; in their communication they built more on earlier messages. The males, who sent more messages, also had more social elements in their communication. Adrianson (2001) also collected data on communication style, and found that females agreed more often than males in responding to messages from males. Also, more opinion changes from females than from males were found.

Carr *et al.* (2004) found that female students were more inclined to focus on collaboration and community building, whereas the conversational styles of male students were more adversarial.

McConnell included control over the direction of the conversation as a measure in his study. No clear gender pattern occurred across the conversations analysed. The other studies in the previous section that found a balanced participation of male and female students in CMC did not look at gender differences in the types of contributions of girls and boys.

Differences in how participation is experienced

No CMC study that we found studied cognitive or affective learning outcomes. Some, however, looked at how students experienced their participation in electronic discussions.

In Hsi and Hoadley's (1997) study, girls not only participated more in the electronic discussion than in the face-to-face classroom discussion, but also appeared to

greatly prefer the former to the latter. They appreciated having time to think before they responded and to be able to respond anonymously, and also liked the absence of immediate (negative) comments from their male classmates.

In Wolfe's (2000) study, there was a close connection between participation and preferences for either electronic or face-to-face discussion. White females, whose participation increased strongly compared with face-to-face discussion, had the strongest preference for the computer-mediated environment, whereas white males had the weakest preference for this type of environment. As a group, the Hispanic women strongly preferred the face-to-face discussion environment in which they were well capable of speaking out and making their opinions heard. They reported feeling ignored in the computer-mediated setting, and were concerned with the loss of non-verbal cues in this environment. Male students were relatively indifferent towards the conversational environment; many of them reported no preference for either environment.

Savicki *et al.* (1996a) found that female-only groups not only produced more words than other groups, but were also significantly more satisfied with the group process and the communication aspects of the computer-mediated experience than either the mixed or male-only groups. Furthermore, female-only groups scored themselves significantly higher in group development.

Bernard *et al.* (2000) studied male and female attitudes towards computer-mediated group interactions. In the study, they randomly assigned 22 male and 32 female college students (mean age 23 years) to computer-mediated groups of three. Each participant was located in a separate room where they read a story in which they were stranded in the subarctic with ten survival items. They were instructed to rank the items on helpfulness to their survival. The group member's task confidence was examined. Males significantly more often believed they developed the best possible ranking. Males were to a marginally significant degree also more satisfied with the interaction process. Males had significantly lower levels of computer anxiety, which may have allowed the males to enjoy the interaction process more. The authors also suggest that a more aggressive style in the males' communication (not studied here, however) may have lowered the females' level of decision confidence and satisfaction.

Summary

Although research results are not unequivocal on gender differences in the degree of students' participation in electronic discussions, the trend in the studies reviewed is to find that male students dominate in CMC. Three of the six studies in which participation of male and female students was directly compared found male students taking more turns or sending more messages. In a fourth study, female participants took more turns than males, but males entered more words per turn. In a fifth study, participation in CMC was more or less gender-balanced. In one study, female students participated more than males in electronic discussions. We would like to suggest two explanations. First, the studies, in which no male dominance in participation occurred, were performed in educational settings with an explicit pedagogical focus on inclusiveness. Second, group composition seems to play a role; there seems to be a trend for male dominance in groups where male students outnumber the female students.

Research results on the type of contributions of male and female participants in CMC point in similar directions. The four studies we discussed that look at communicative styles report the following differences: assertiveness, disagreement and the presence of social elements seem to be typical of male styles in CMC. Females are more attuned to the task and to collaboration, build more on earlier messages and agree more with males than males with each other. Three studies report on differences in communication style between male-only and female-only groups. Tension, abusive language, attacks, calls for action and sticking to one's opinion seem to be more prevalent in male-only groups than in mixed of female-only groups. In female-only groups, more expression of individual opinions, milder or more intense reactions to other persons, more self-disclosure and more attempts at tension prevention or reduction are found. None of the studies into gender-related communication patterns looked at educational settings in which inclusiveness was an explicit issue.

There is a tendency to find that girls and women prefer CMC discussion to face-to-face discussion. Female-only groups seem to be more satisfied with the group process and the communication than mixed or male-only groups. But females in mixed groups seem to be less satisfied with the interaction process than males.

Gender differences in CSCL

In CSCL, the uses of ICT and communication and discussion are of a specific character: their aim is to build knowledge collaboratively. Based on the results of studies into gender differences in the educational use of ICT, we expect that CSCL will appeal to girls; opportunities for collaboration and communication are both mentioned as characteristics that make ICT applications attractive for girls. Based on our analysis of CMC studies, we expect a participation in CSCL to be more equitable than in CMC, because we expect that in CSCL rules for collaboration are more explicitly addressed. We expect that the character of the contributions of girls and boys will be of a different kind, unless the instruction explicitly focuses on the kinds of contributions that are considered valuable. In this section, we review the literature on CSCL and gender differences, and analyse what empirical evidence there is for these expectations. First, we look again at differences in degree of participation, and we then discuss differences in type of participation. We did not find any studies that looked at gender differences in learning outcomes in CSCL or in how students experienced participation in CSCL. Relevant details of the studies discussed are summarized in Table 2.

Differences in degree of participation

Palonen and Hakkarainen (2000) analysed patterns of elementary students' peer interaction in a computer-supported classroom (grade 5/6) using the Computer-Supported Intentional Learning Environment (CSILE). The study involved a qualitative analysis of students' written productions, posted to the CSILE's database, in the context of three Physics projects and one Biological Science project. Students were expected to engage in 'progressive discourse', i.e. in peer interaction focused on providing and requesting explanations that facilitate advancement of the explanations of the group. Two-thirds of the students ($n = 19$) were female and one-third ($n = 9$) male. Discourse interaction was analysed by applying social network analysis examining the intensity of direct interaction among members of the learning community, the extent of each member's participation and patterns of interaction in the community as a whole. The analysis revealed that average- and high-achieving females dominated discourse interactions within the CSILE class and carried the main responsibility for all students' collaborative building of knowledge. Male students' communication took place mostly between average and above average males. The results further revealed that a significant amount of communication took place between students that represented different achievement levels, whereas female and male students seemed mainly to interact within their respective gender groups.

Tapola *et al.* (2001) included gender in their study of motivation and participation in a CSCL environment (Virtual Web School). They also used social network analysis. A total of 31 fifth grade elementary students and one teacher participated in the study, which focused on analysing the students' activities in two study projects in History, using four networked computers. In this study, the gender distribution of the participants was balanced. Tapola *et al.* (2001) found that student participation was not equal and that it was mainly the high learning-oriented students who engaged actively in CSCL. However, the results did not show the same kind of drastic gender-related differences in the intensity of participation as found by Palonen and Hakkarainen (2000). This may be attributed to the differences in the gender balance of the participants in both studies. The results were also more optimistic about interaction across gender and motivational orientation boundaries. Unfortunately, we have no further information that may help interpret these findings in terms of a classroom culture focused on inclusiveness.

In another study, Hakkarainen and Palonen (2003) again found a more prominent role in the discussion for female students in a class (fifth and sixth grade) with a majority of girls, and for boys in a boy-dominated class. The data consisted of productions of two parallel grade 5 and 6 elementary classes that used CSILE in their classroom routines over a period of 1 year ($n = 58$). In classroom A (19 females, nine males), students were guided to engage in a very intense research-type process of inquiry; in classroom B (ten females, 20 males), the learning environment was used to support traditional school work. Network analysis indicated that classroom A's interaction was not very centralized and that most active students were found among the female students. Classroom B's interaction was fairly centralized, indicating that certain individuals, exceptionally active male students, were keeping up the interaction. The difference in the intensity of female and male

Table 2. Details and results of the CSCL studies.

References	Number of subject, level	(Main) objective/ research question	Design	Methodology: data	Application, task and content	Grouping	Instructions (structure provided for interaction)	Results
Hakkarainen and Palonen (2003)	*n* = 58, grade 5/6	Participation of female and male students	Descriptive	Content analysis and social network analysis	CSCILE, structured process of inquiry, physics and biology	Class A: F = 19, M = 9, Class B: F = 10, M = 20	The students posted daily 'notes'	Class A: females dominated, Class B: males dominated (male and female). Class A: females and males – more explanation-related comments
Li (2002)	*n* = 22, elementary (6th grade)	Gender differences in students communication and interaction	Descriptive	Qualitative coding, unit counting	Knowledge forum, ?, mathematics and science	(11 F, 11 M)	–	Females: longer messages, more 'information requesting', fewer 'explanation providing', more initiating
Lipponen *et al.* (2003)	*n* = 21, elementary (age 10.5)	Elementary students' participation and discourse	Descriptive	Social network analysis, qualitative content analysis	CSILE, generating own research questions, energy, environment, biology	(10 F, 11 M), pairs or small groups equal	Encouragement for writing research questions, explanations and comments, for the good of the whole class	Girls commented actively on boys' notes and vice versa
Palonen and Hakkarainen (2000)	*n* = 28, elementary	Patterns of peer interaction	Descriptive	Qualitative analysis, social network analysis	CSILE, progressive discourse interaction, physics and biology	(19 F, 9 M), 2/3 female, 1/3 male	–	Average- and high-achieving females dominated; interaction mainly within gender groups. Females: sharing intuitive conceptions. Males: authoritative statements
Tapola *et al.* (2001)	*n* = 31, fifth grade elementary	Motivation and participation in a CSCL environment	Case study	Questionnaire, social network analysis	Virtual web school, networked computers, collaborative knowledge-building, history	balanced	?	Mainly the high learning-oriented students engaged actively
Robertson *et al.* (2003)	*n* = 40, post-secondary level	–	Case study	Note and word count	Web knowledge forum, discussion of assigned articles	–	The quality and timeliness of their contributions was considered in their final grade	Males: more notes but not more words per note

CSCL, computer-supported collaborative learning; CSILE, Computer-Supported Intentional Learning Environment; F, female; M, male.

students' participation might be attributed to the unequal gender distribution in both classrooms, but might also be attributed to the different classroom cultures, with girls participating more in collaborative knowledge building, and boys in a traditional task-based pedagogical model. Further network analysis indicated, again, that students preferred to communicate within their own gender group in both classrooms. The density of mutual interaction of females in classroom A was remarkably high, substantially higher than for the corresponding interaction between male students in classroom B. The density of interaction between male and female students in classroom A was particularly low. In contrast, the density of comments sent by female to male students was somewhat higher in classroom B.

Robertson *et al.* (2003) carried out an analysis similar to Hakkarainen and Palonen (2003) at the post-secondary level. The students met for 3 h once a week for a discussion of some assigned articles. In addition, they were required to start the discussion the week prior to each meeting in WebKF. The quality and timeliness of their online contributions was considered in their final course grade. Robertson *et al.* (2003) also uncovered gender-specific trends in the Knowledge Forum behaviour patterns of men and women. Men posted more notes than women, but, proportionally, did not write more words per note.

In an overview of a number of CSCL case studies, Lipponen (1999) reports that in every CSILE project conducted by him until that time, boys had been more active, i.e. posting more notes to the CSILE database than girls. Lipponen illustrates his statement with several examples. In a study into a 4-week course on 'Energy' (11–12-year-old students), for example, the relative proportion of notes by females ($n = 13$) was 29.5%. The relative proportion of notes by males ($n = 14$) was 70.5%. However, according to the author, the extent of active participation does not reveal a great deal about the quality of the knowledge produced.

A study by Lipponen *et al.* (2003) studying elementary students' participation and discourse did show an equal spread of communication among gender groups. The study included ten girls and 11 boys with an average age of 10.5 years, and concerned three consecutive projects on 'energy', 'map and environment' and 'biological adaptation' in which students generated their own research questions and worked in pairs or small groups on various subtopics. As a response to previous research indicating that the quality of discourse in CSCL environments was low, criteria for effective and high-quality participation were formulated: sustained discussion, broad participation, discussion focused on the class learning topics, dense, not-centralized interaction, reflective and constructive discourse. Participation was analysed using social network analysis. A content analysis was used for analysing the quality of discourse. Girls appeared to comment actively on boys' notes and vice versa, as was shown by the network density values within and among gender groups. These findings contradict those of Palonen and Hakkarainen (2000), who found that density of interaction among male and female students was low. In their study, boys mainly sent comments to boys, and girls to girls, but the gender distribution in the groups in their study was unequal.

With regard to our review, an interesting question is whether there is a relationship between network position and gender. Lipponen *et al.* (2003) found that popularity (and central position in the social network) influenced participation. Cho *et al.* (2002) show that social influences, in the form of network prestige effects, strongly affect the extent to which information, posted in CSCL tools, was actually shared by peers in this learning community. The likelihood of information exchanges between peer members and the amount of information shared were at least partly determined by characteristics of actors like position and prestige, regardless of content or information value of the contributions. However, gender was not included as a variable in their studies.

Differences in type of participation

Gender differences in communicative styles have not been studied as extensively in CSCL as in CMC. Nevertheless, some differences have been found. In Palonen and Hakkarainen's (2000) study, in which a dominance of average- and high-achieving girls was observed in the interaction, gender differences in the type of contributions were also reported. Female students seemed more willing to share their own intuitive conceptions and theories, while male students generally preferred to post authoritative statements of scientific knowledge. Their postings did not appear to provide as fruitful a starting point for lively discussion as female students' postings.

Li (2002) examined communication and interaction by boys and girls ($n = 22$) in a sixth grade primary class,

using Knowledge Forum. The interaction was analysed in terms of the length of the messages and the extent to which messages build on earlier messages. The transcripts of the interactions were coded for language functions, including requesting information, presenting opinions and providing explanations. Li found that female students' messages contain significantly more 'information requesting' than male students' messages. Female initial messages included significantly fewer 'explanation providing' messages than male initial messages. Also female students tended to initiate discussions more often. The length of female students' messages appeared to be significantly greater than those of male students.

Robertson *et al.* (2003) argue that, rather than viewing gender differences in communicative style as a problem, the differences should be seen as facilitating the creation of knowledge. They argue that the adversarial, competitive style of males can provide a challenging atmosphere for knowledge building, while the female-supportive style can facilitate the sharing of ideas. However, the authors did not include study of such differences in their CSCL research.

In the study in which Hakkarainen and Palonen (2003) compared a female-dominated class A, engaged in a research-type process of inquiry, and a male-dominated class B in which CSCL was used to support traditional school work, students' contributions to the database were also classified according to the type of communicative idea. Ideas were coded along the following parameters: whether they supported the notes commented on by expressing agreement, whether they represented a neutral exchange of ideas, or whether they were critical in nature and expressed disagreement. Communicative ideas were further analysed by specifying whether the idea concerned linguistic form, research questions, research methods, information, method of explanation and other, or unspecified matters. Finally, students' discourse interaction was analysed by applying social network analysis. A classroom comparison showed that the (male and female) students in classroom A produced a higher mean proportion of explanation-related comments than those in classroom B. Classroom A students also engaged in more advanced processes of inquiry than classroom B. This is not surprising, considering the different pedagogical cultures of the classrooms.

Summary

The tendency in the studies discussed is that boys participate as much as or more intensely in CSCL environments than girls, but dominance of girls does also occur. In two of the six studies a more active role of boys was found, and in two studies a balanced participation was found. In one study, the results varied according to the gender composition of the classroom. This study suggests that female students may play a more prominent role than boys in female-dominated classes. This hypothesis is supported by the fact that the only study in which female students were the more active participants in the communication was performed in a female-dominated class. It is difficult to interpret the findings in terms of the extent to which classroom cultures are focused on inclusiveness, as the information on the settings of the studies is often limited. In one of the studies where a balanced participation was found, however, it is reported that explicit criteria were set to enhance high-quality participation, including 'broad participation'. Two of the four studies that look at communication across gender groups conclude that students prefer to communicate within their own gender group. The two other studies did not find this pattern. In one case, this may be explained by the fact that students worked according to criteria for high-quality participation, including 'not-centralized discussion'.

Indications of gender differences in type of participation are also found in CSCL. Females tend to share their intuitive conceptions while males post more authoritative statements. Females ask more questions but provide fewer explanations than males. One study found that females initiated more discussions. An inquiry learning culture seems to enhance the production of explanation-related comments of both male and female students. We did not find any information about differences in the appeal of CSCL to girls and boys.

Conclusion and discussion

In this review study, we focused on gender differences in students' degree and type of participation and their learning outcomes in two particular kinds of using ICT in education, CMC and CSCL. Studies into CMC show that, although the communicative character of this kind of use of ICT may be expected to influence its attractiveness for female students positively, male dominance and

gender differences in communication style continue to play a role in CMC settings. Male students tend to dominate in CMC. Male participants are also found to be more assertive, disagree more and contribute more social (off-task) elements to the discussion. Females were found to be more attuned to the task and to collaboration, to build more on earlier messages and to agree more. Also differences in communication style between male-only and female-only groups were found, with tension, abusive language, attacks, calls for action, and sticking to one's opinion being more prevalent in male-only groups, and expression of individual opinions, mild or intense reactions, self-disclosure and attempts at tension prevention or reduction being more prevalent in female-only groups. We found indications that participation was more gender-balanced in educational settings with an explicit focus on inclusiveness in collaboration.

The results of our review of CSCL studies also show a tendency for boys to be more active participants in CSCL environments than girls, but the difference is less pronounced than in CMC. Female students were found to play a more prominent role than boys in female-dominated classes. Special attention for inclusiveness in participation again seems to be relevant. Gender-related types of participation and communication patterns have not been researched as extensively in CSCL as in CMC. Some differences have been found in the character of girls' and boys' contributions to CSCL discussions. Female students were found to be more inclined to share their own intuitive conceptions and theories, to initiate discussion and to request information. Male students were found to post more authoritative statements and to provide information more often.

In this review, we examined gender differences across different types of technological mediation and across institutional settings and age groups. Gender differences in participation and gender-stereotyped patterns of communication do occur in both types of technology-mediated discussion. The differences found are in line with gender differences in conversational styles that are found more generally (e.g. Maccoby 1990). However, such differences seem less pronounced in CSCL than in CMC. We may wonder whether this is due to the younger age of most students in CSCL research, the setting of the studies or a merit of CSCL environments as such. Although age may play a role, we also want to suggest some interpretations that are more amenable to pedagogical intervention.

Whereas research in CMC includes studies both in artificial situations in which collaborating groups are especially created with a view to the research, and in settings where CMC is used as part of an educational programme, all CSCL studies focused on existing classes engaged in collaborative knowledge-building work. Although we have little information on the way students' collaboration was guided and supported by the teachers, on the classes' experience with this kind of work and on classroom cultures, we do know that students in CSCL are always in some way instructed to collaborate as a learning community according to certain rules and are supported by the software to do so. This kind of support may mitigate the extent to which gender-stereotyped patterns of participation and communication occur in the classroom. Conspicuously, in one of the studies where a gender-balanced participation was found, a classroom culture was created in which inclusion was seen as an indication of high quality of the discussion, just as was the case in the CMC studies with a balanced participation. It may therefore be worthwhile to experiment with interventions in which inclusiveness in participation is explicitly addressed in the 'rules' guiding the collaboration in CSCL. The results of studies on gender differences in the educational use of ICT in which structured interventions were used aimed at diminishing gender-stereotyped interaction are promising (Pryor 1995; Ching *et al.* 2000).

Some authors, however, downplay the phenomena of differences between students in participation and communication styles. Robertson *et al.* (2003), for example, argue that gender differences should not be seen as a problem, as both male and female styles are necessary in the process of knowledge construction. Carr *et al.* (2004) argue that the rather limited participation of some students in online chats in their study could be interpreted as 'peripheral participation', in Wenger's (1998) sense. Instead of participants being marginalized, they see limited participation as a stage on the road to full participation. Others suggest that teaching staff should employ early interventions, including rapid identification of peripheral members in a learning community to help them become more active members in community-based practices.

Although we acknowledge that different roles in collaborative learning may contribute to the learning process or may reflect different stages in the development of student participation, we think there is reason for concern when the distribution of roles appertain to categories like gender, achievement level or sociocultural background. Moreover, we do not believe that students benefit from taking one and the same role in the group for longer periods of time. The question of marginalization or peripheral participation can only be answered by monitoring student participation patterns so as to establish whether ways of participating are, in fact, subject to development. Where such development is absent, more balanced forms of participation should be strived at, both by engaging peripheral participants and socializing the whole group into a more inclusive classroom culture. Also we would urge alertness to the fact that students do not one-sidedly act in only one kind of group role. Students should be assisted in developing a broad repertoire of communicative styles and roles.

We are bound to conclude that a great deal of work still has to be performed. Many of the hypotheses with which we started our review remain open to further study. The studies that we found are mainly small-scale, conducted in different educational contexts, in which several aspects in addition to gender may explain the differences found: proportion of males to females in the group, age of the students, achievement level, task type and instruction, etc. Most studies were not designed to address gender issues, and do not provide much information that helps explain the variance. Nevertheless, we found indications for factors that increase or diminish gender-stereotyped patterns of participation and communication. Future research could also provide insight into such factors in relation to participation by students who differ in social and ethnic background, ability level and status or popularity.

We did not find any studies in which the relationship between the quantity or quality of students' participation and cognitive and affective learning outcomes is addressed. Given that some authors question the importance of differences in participation and of the distribution of roles in collaborative groups, insight into the effects of participation becomes all the more relevant. Finally, our review indicates that it is relevant to focus research on the question of how classroom cultures can be promoted that support active participation of all students aimed at collaborative knowledge construction.

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